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FRANKLIN, OHIO'S SOLID WASTE DISPOSAL AND FIBER RECOVERY DEMONSTRATION PLANT.

VOLUME I

A. M. KINNEY, INCORPORATED

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

1974

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The Franklin, Ohio, resource recovery demonstration project has elicited widespread interest. This report was prepared to: (1) present a preliminary analysis of the solid waste disposal and fiber recovery portions of the project; (2) provide preliminary data by which others may be guided in evaluating emerging solid waste disposal and resource recovery technologies. The historical development of this EPA-sponsored project and a general description and evaluation of the process used are included. The preliminary plant economics presented are based on construction costs and the first 12 months of operation. The plant began functioning in June 1971 and is now in regular operation recovering ferrous metals and paper fibers which are sold to local industries.

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17b. Identifiers/Open-Ended Terms
*Solid waste disposal, *Resource recovery, Fluid bed incinerator, Solid waste separation technology, Liquid cyclone separator, Paper fiber recovery system, Sewage sludge disposal, Franklin (Ohio)

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FRANKLIN, OHIO'S

SOLID WASTE DISPOSAL AND FIBER RECOVERY DEMONSTRATION PLANT

Final Report

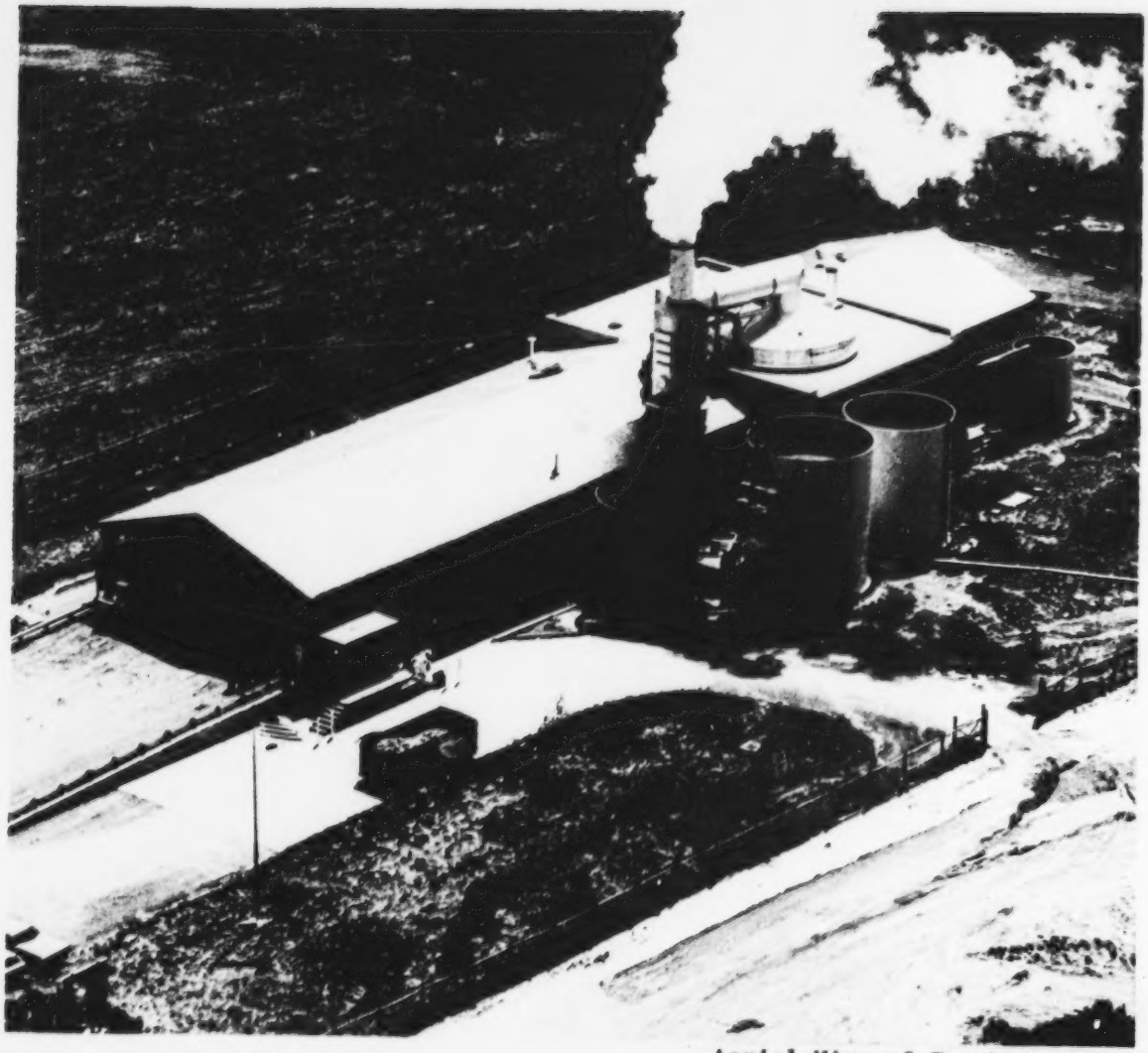
VOLUME I

This report (SW-47d.1) was prepared
for the City of Franklin, Ohio, under demonstration grant No. G06-EC-00194
from the Office of Solid Waste Management Programs
by N. THOMAS NEFF and N. WAYNE OKEL
A. M. Kinney, Inc., Consulting Engineers, Cincinnati, Ohio
A summary report (SW-47d.3) on this project is being published
by the U.S. Government Printing Office

U.S. ENVIRONMENTAL PROTECTION AGENCY
1974

This report has been reviewed by the U.S. Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of commercial products constitute endorsement or recommendation for use by the U.S. Government.

An environmental protection publication in the solid waste management series (SW-47d.1).



Aerial View of Franklin Plant

FOREWORD

The initial objective of this project, started in 1968, was to demonstrate an innovative solid waste disposal technique utilizing wet grinding and subsequent incineration. Later the scope of the project was expanded to recycle portions of the solid waste stream. The facility located in Franklin, Ohio, and designed and operated by the Black Clawson Co., presently includes the capability to separate reusable paper fibers and ferrous metals for recycling prior to disposing of the remaining solid wastes. Further construction has recently been completed which has added to the plant the capability to recover color-sorted glass and aluminum. This pilot plant represents one of the first successful resource recovery facilities in the country.

In addition to disposing of all the municipal solid wastes generated in Franklin, Ohio, the plant also incinerates sludge from a nearby sewage treatment plant. This project represents a significant advance in the state of the art of resource recovery and residuals management. This small system is a completely unique environmental control complex which has been toured by visitors from many parts of the world.

This report is based on data collected during the first 12 months of plant operation, i.e., June 1971 through May 1972. As such, much of the information and conclusions presented herein are outdated. Nevertheless, this report, in two volumes, does present much data which may be of interest to people in the solid waste management and resource recovery fields. Hence the report was prepared for publication.

The plant has continued to run on a regular basis since May 1972, and a more rigorous and comprehensive evaluation program is now underway. The current evaluation is being conducted under a separate EPA contract with the Systems Technology Corporation (Systech) of Dayton, Ohio. Their report should be available in early 1975. We wish to acknowledge the contribution made by David G. Arella, who served as the government's officer on this project from December 1971 to August 1974.

— ARSEN J. DARNAY
Deputy Assistant Administrator
for Solid Waste Management

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ABSTRACT

Title: System for total refuse disposal by fluid mechanical separation of solid wastes and fluid bed oxidation of combustibles, and reclamation of paper fibers.

Grantee: City of Franklin, Ohio
35 East Fourth Street
Franklin, Ohio 45005

Project Director: Bernard F. Eichholz, City Manager

Project Started: Sep. 24, 1968

Project Ended: Feb. 28, 1973

Project Objectives: To design, construct, operate, and evaluate a demonstration plant for disposal of municipal solid waste and for the recovery of metals, glass, and paper fibers therefrom.

The system was designed to receive virtually unsorted municipal solid waste and to separate it by using a fluid-mechanical process. Reusable paper fibers, metals, and noncombustibles are separated in the process, and the remaining combustible solids are mixed with sewage sludge from an adjoining sewage treatment plant, and then burned in a fluid bed incinerator.

Results of Project: The plant is in daily commercial operation as the principal solid waste disposal facility for the City of Franklin and adjacent areas. The technical capability of the Wet Processing and Disposal system has been successfully demonstrated. The Fiber Recovery system initially produced yields of paper fiber lower than anticipated, but has undergone further developmental work to increase yield.

Actual operating costs during the term covered by this report are higher than originally anticipated due to low usage (40 tons per day) and due to

inflation. However, sufficient data and operating experience have been obtained to permit cost projections for plants of larger capacities, which indicate lower operating costs.

Summaries, tables and graphs are included to present actual construction and operating costs, as well as influent and effluent operational data.

This report was submitted in fulfillment of Project No. G06-EC-00194 under the partial sponsorship of the Office of Solid Waste Management Programs, Environmental Protection Agency.

FOR MORE INFORMATION ABOUT THE FRANKLIN PLANT

Solid Waste and Fiber Recovery Demonstration Plant for the City of Franklin, Ohio: An Interim Report. N.T. Neff. U.S. Environmental Protection Agency, 1972. 83 p. Distributed by National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22152, as PB-213 646. Price for paper copy is $4.85; for microfiche, $1.45.

Waste Processing Complex Emphasizes Recycling. William Herbert and Wesley A. Flower. Public Works, 102(6): 78-81, June 1971. Reprinted by Office of Solid Waste Management Programs, U.S. Environmental Protection Agency, 1972.

Glass and Aluminum Recovery in Recycling Operations. William Herbert and Wesley A. Flower. Public Works, 102(8): 70, 110, 112, August 1971. Reprinted by Office of Solid Waste Management Programs, U.S. Environmental Protection Agency, 1972.

Solid Waste Recycling at Franklin, Ohio. William Herbert. In Proceedings of the Third Mineral Waste Utilization Symposium, Chicago, March 14-16, 1972. (Jointly sponsored by U.S. Bureau of Mines and Illinois Institute of Technology Research Institute.)

Arella, David G. Wet-Processing Solid Waste for Resource Recovery: A Summary Report on the Franklin, Ohio, Demonstration Project. Summary report (SW-766a). Grant No. G06-EC-00194. U.S. Environmental Protection Agency, Washington, DC 20460. (In press.)

SECTION I - SUMMARY AND CONCLUSIONS

A. Summary. Evaluation of cost and operational data obtained during the demonstration operation period of the Franklin, Ohio, Solid Waste Disposal and Fiber Recovery Plant shows that the system for solid waste disposal has been successful. The fiber recovery system initially produced yields of paper fiber less than anticipated, but has undergone further developmental work to increase yield. The solid waste disposal portion of the plant has been in operation since May 1971, and the fiber recovery portion has been in operation since June 1971.

The Franklin project has grown from two simple objectives into a multi-faceted complex with additional primary objectives and several corollary projects. Originally, the objectives were:

1. To demonstrate, on a commercial scale, the Hydrasposal* system for disposal of municipal solid waste. This is an innovative wet-grinding and fluid separation process whereby noncombustibles are removed for recycling or landfilling, and the organic residue is burned in a fluid bed reactor.

2. To provide an economical means for disposal of the solid waste from the Franklin area, since the capacity of the City's landfill would reach its limit in another three or four years.

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*Copyrighted trademarks of The Black Clawson Company, Middletown, Ohio, for systems for the disposal of solid wastes and for the recovery of paper therefrom, covered by various U.S. patents.

In rapid succession, other primary objectives were added to the project. These were:

3. To demonstrate the Fibreclaim* process for recovery of paper fiber from wet-ground municipal solid waste.

4. Magnetically separate and reclaim ferrous metals from the Hydrapulper* reject stream.

5. Demonstrate that raw sewage sludge can be burned in conjunction with the organic residue from the Hydrasposal process, thereby eliminating the need for sludge digestion equipment in an associated sewage treatment plant.

Other corollary projects have evolved as a result of this demonstration facility. These are:

1. A waste glass reclamation process presently is being built to receive the reject stream from the liquid cyclones, and further process it to separate an aluminum fraction, as well as color-sorted glass cullet. This demonstration facility is being jointly funded by the Environmental Protection Agency and the Glass Container Manufacturer's Institute.

2. An industrial liquid waste disposal facility presently is in the early planning stages. This plant would utilize the fluid bed reactor portion of the Hydrasposal system to incinerate the collected and blended wastes during times when the reactor is not being used to incinerate solid waste and sewage sludge. This facility is expected to safely dispose of approximately 14,000 gallons per day of oils and solvents, which are now being dumped on the land, or otherwise disposed of in a polluting manner.

B. Response to Objectives. The operational data presented in this report show the following response to these objectives:

1. Routinely, on a commercial scale, essentially unsorted municipal solid waste is being successfully wet-ground and separated in the Hydrasposal system.

2. The volume of material going to landfill has been reduced by approximately 95 percent. During the period that the plant has been in operation, it has never been necessary to divert collection trucks to the former landfill for the disposal of Franklin's garbage.

3. Relatively small ungrindable items, such as tin cans, are being removed from the Hydrapulper slurry and the ferrous fraction is being magnetically separated and sold for recycling as scrap metal.

4. Recyclable paper fiber is being removed from the slurry by the Fibreclaim process.

5. The nonrecoverable organic residue is being burned in a fluid bed reactor in conjunction with raw sewage sludge from the adjoining sewage treatment plant.

While fiber recovery is being achieved, the rate of recovery is substantially less than initially predicted. The recovered fiber is regularly pumped as a slurry to a nearby manufacturing plant which buys it for use in conjunction with other fibers to produce roofing felt.

The cost data reported by the plant operators, Black Clawson Fibreclaim, Inc., indicate that the Franklin plant is not commercially viable at the present throughput rate. If the tonnage received could be increased to full capacity, Black Clawson projects that operating losses could be reduced. (See Economic Evaluation Section.)

C. Conclusions. The conclusions that may be drawn from this evaluation are as follows:

1. The technical successes achieved in operating this plant have warranted the Federal support received, and have advanced the technology of solid waste disposal and resource recovery methods.

2. Continued Federal support in funding additions and improvements to the plant would be warranted and would provide the means for significant innovations in the technology of a now-proven process.

3. The impact on the environment of the Franklin plant is favorable, and the planned expansion of the plant will be entirely consistent with all environmental objectives.

4. On the basis of the information obtained from Black Clawson, commercial viability is clearly a function of plant throughput.

D. Recommendations. On the basis of these evaluations and conclusions, the following recommendations are made.

1. The City of Franklin, Ohio, should continue the operation of the facility and endeavor to renew its operating contract with Black Clawson Fibreclaim, Inc., with modifications suggested in Recommendation 2 below.

2. Although the plant is a developmental and sales tool for Black Clawson, the City should allow Black Clawson to increase dumping fees, consistent with Federal price increase guidelines, and thus make Black Clawson's continued participation more attractive to Black Clawson.

3. The independent evaluation study proposed by the Environmental Protection Agency, Office of Solid Waste Management Programs, should include provision for additional and improved operational monitoring instrumentation

that it was not possible to provide within the limited funds available for the original construction; and a rigorous, analysis of all operating costs, which was not obtainable for the purposes of the evaluation.

SECTION II - HISTORY AND DEVELOPEMENT OF PROJECT

The Franklin project was begun in 1968, when the city realized that its landfill would be full in another 3 to 4 years. Studies of new sites were meeting the usual opposition from residents who did not want a landfill near their properties.

One of the members of the Franklin City Council was Mr. Joe Baxter, Jr., an engineer employed by the Shartle-Pandia Division of The Black Clawson Company, Middletown, Ohio, manufacturers of paper mill machinery. Mr. Baxter conceived the idea of utilizing an array of this machinery to pulp solid wastes, automatically eject nonpulpable objects from the pulper, hydrodynamically separate finely chopped noncombustibles, and burn the residual pulped combustibles in a fluid bed reactor, in the same manner as sewage sludge is burned.

Entirely at the expense of The Black Clawson Company, a pilot plant was built in the Research and Development Laboratory of their plant at Middletown, to prove that the idea was feasible. The Black Clawson Company retained the services of A. M. Kinney, Inc., Consulting Engineers, to evaluate the process. Pilot plant tests showed that municipal solid waste could be pulped in a Hydrapulper, that the noncombustible content of the refuse could be separated from the organic residue, that mixing sewage sludge with the combustible remainder increased the filterability of the sludge, and that the remainder being land-filled and covered biweekly constituted a 90 to 95 percent reduction in landfill volume.

Since the Middletown pilot plant did not include a fluid bed reactor, other pilot operations were performed to determine the combustion characteristics of the pulped organic residue. Pilot plant tests were performed in a Copeland

reactor and a full scale test was made in the Dorr-Oliver, Inc., sludge-burning reactor at the Ocean City, Maryland, sewage treatment plant, both using organic rejects from the Middletown pilot plant.

On the basis of the feasibility study, application was made, under the Solid Waste Act of 1965, for a demonstration grant to design and build a plant in Franklin, Ohio, using commercial-size equipment, which would demonstrate this innovative method at minimum cost, and at the same time would solve the solid waste problem of the City of Franklin.

Grant No. 1-D01-U1-00194 was received on Sep. 24, 1968, and the City retained A. M. Kinney, Inc., to prepare a preliminary Design Manual to establish design concepts and estimated construction costs.

During this period, the Miami Conservancy District became responsible for the water quality of the Great Miami River, and started planning a regional sewage treatment plant for the Franklin area. They acquired a tract of land adjacent to the southwest edge of the City, and offered a part of this property to the City as the site for the solid waste plant. The inter-relationship of the two plants is shown in Figure 1. Provisions were made in the construction of the solid waste plant for the connections to the sewage treatment plant which was completed after the solid waste plant was in operation.

Also during this time, further developmental work was done by The Black Clawson Company in the application of other paper mill-type equipment to the separation of reusable paper fiber from the aqueous slurry. The pilot plant at Middletown was expanded to prove the feasibility of this process. On the basis of the pilot plant results, a supplementary grant application was made and funds were awarded to include the Fibreclaim process in the Franklin plant.

The solid waste system Design Manual and the fiber recovery system Design Manual, both prepared by A. M. Kinney, Inc., for the City of Franklin, formed the bases for award of the construction grants No. 2-G06-EC-00194-02 and 3-G06-EC-00194-1S1, which was made on Mar. 2, 1970. Final design drawings and specifications were then prepared, and lump sum bids were solicited in accordance with the laws of the State of Ohio governing bidding for municipal projects. Construction and equipment contracts were awarded, and A. M. Kinney, Inc., was retained by the City to supervise construction of the plant.

While the solid waste and fiber recovery plant was being built, the Glass Container Manufacturers Institute (GCMI) announced that it had completed a series of tests and trial operations using the glass-rich fraction separated from the pulped refuse by the liquid cyclone in the Middletown pilot plant. Using a train of screening and classifying equipment to separate extraneous material, the GCMI equipment train was capable of recovering an aluminum-rich stream and color-sorting glass cullet using a Sortex optical sorter.

GCMI proposed that the City of Franklin apply for a supplementary grant to add this subsystem to the Franklin plant, on the condition that GCMI would reimburse the City for the matching funds. Award of this grant (No. 3-G06-EC-00194-03S2) was made by the Environmental Protection Agency, Office of Solid Waste Management Programs on June 8, 1971. Construction of this addition is now complete and initial operation began in July, 1973.

Construction of the solid waste plant was completed on May 17, 1971, and the fiber recovery plant was completed on June 28, 1971. The plant was dedicated on Aug. 11, 1971, by Mr. Richard D. Vaughan, then Director of the Office of Solid Waste Management Programs, Congressman Walter E. Powell of the 8th District of

Ohio, and Mr. Bernard F. Eichholz, City Manager, City of Franklin, Ohio.

The Miami Conservancy District (MCD) in expanding its role from flood control of the Great Miami River to that of total water management of that stream, recognized that a major source of pollution was industrial waste liquids being dumped in sewers, streams, and land draining to the river. The MCD commissioned a survey study of these pollutants and of possible alternative disposal center be built at Franklin to take advantage of the Hydrasposal system's integral fluid bed reactor. The reactor at Franklin is capable of incinerating many of the industrial liquid wastes, and is expected to be used a maximum of two shifts per day, five-and-a-half days per week through most of the 1980's.

The City of Franklin retained A. M. Kinney, Inc., to prepare specifications for the design, construction, and operation of a receiving, storage, and blending facility to be added to the solid waste recycling-sewage treatment complex. Proposals were received by public bidding, and a firm was selected to operate the industrial liquid disposal facility, conditional upon receipt of Federal assistance. Application for a Federal grant to build the facility was made by the City.

Although there is more to be added, the Franklin Environmental Control Complex has attracted inquiries and visitors from many parts of the world.

Because it is a commercial plant, operating in regular daily service to the City and its environs, and demonstrates a new approach to resource recovery and solid waste disposal, visitors have come from nearly every state of the Union, and from such foreign countries as Sweden, Australia, Italy, Japan, and Great Britain to observe its operation.

The future of the plant is not only a function of the completion of the other parts of the complex, but is largely dependent upon the economic viability of its operation. The process lends itself to more innovation, so that other recovery facilities may be added in the future to reduce its operating costs. In addition, the Franklin area is experiencing a rapid residential and commercial growth rate, as a result of which the economics of increased throughput may be realized in the foreseeable future.

SECTION III - OPERATIONS ANALYSIS

A. General Description of Process. In the overview, the Solid Waste Disposal and Fiber Recovery Plant is composed of two major divisions, the Hydrasposal System and the Fibreclaim System. Each of these integral systems may be considered to be composed of several subsystems. The flow of material through the plant, and the relationship of the plant to the Sewage Treatment Plant, is shown in Figure 1. The physical arrangement of equipment within the Solid Waste Disposal and Fiber Recovery Plant is shown in Figure 2.

1. Hydrasposal System

a. Receiving and Weighing Subsystem. As shown in these diagrams, refuse is delivered to the plant by private contractors and individual citizens. All incoming refuse, except that from passenger vehicles and small pickup trucks, is weighed and recorded at the scale. The vehicles dump their loads onto the concrete receiving floor, as shown in Figure 3 from which the refuse is pushed onto the feed conveyor by a front-end loader.

b. Wet Grinding and Separation Subsystem. The conveyor feeds the refuse into the Hydrapulper at a controlled rate, as shown in Figure 4. The Hydrapulper is a Black Clawson Model SW pulping machine, 12 feet diameter, and equipped with a 300 horsepower motor. Water which has been removed from subsequent stages of the process, and fresh water from the sewage treatment plant discharge are mixed with the refuse, and all pulpable and friable materials are converted by the action of a high speed cutting rotor in the bottom of the Hydrapulper tub into a water slurry having approximately 4 percent solids content. Pieces of metal, tin cans, and other nonpulpable and nonfriable materials are

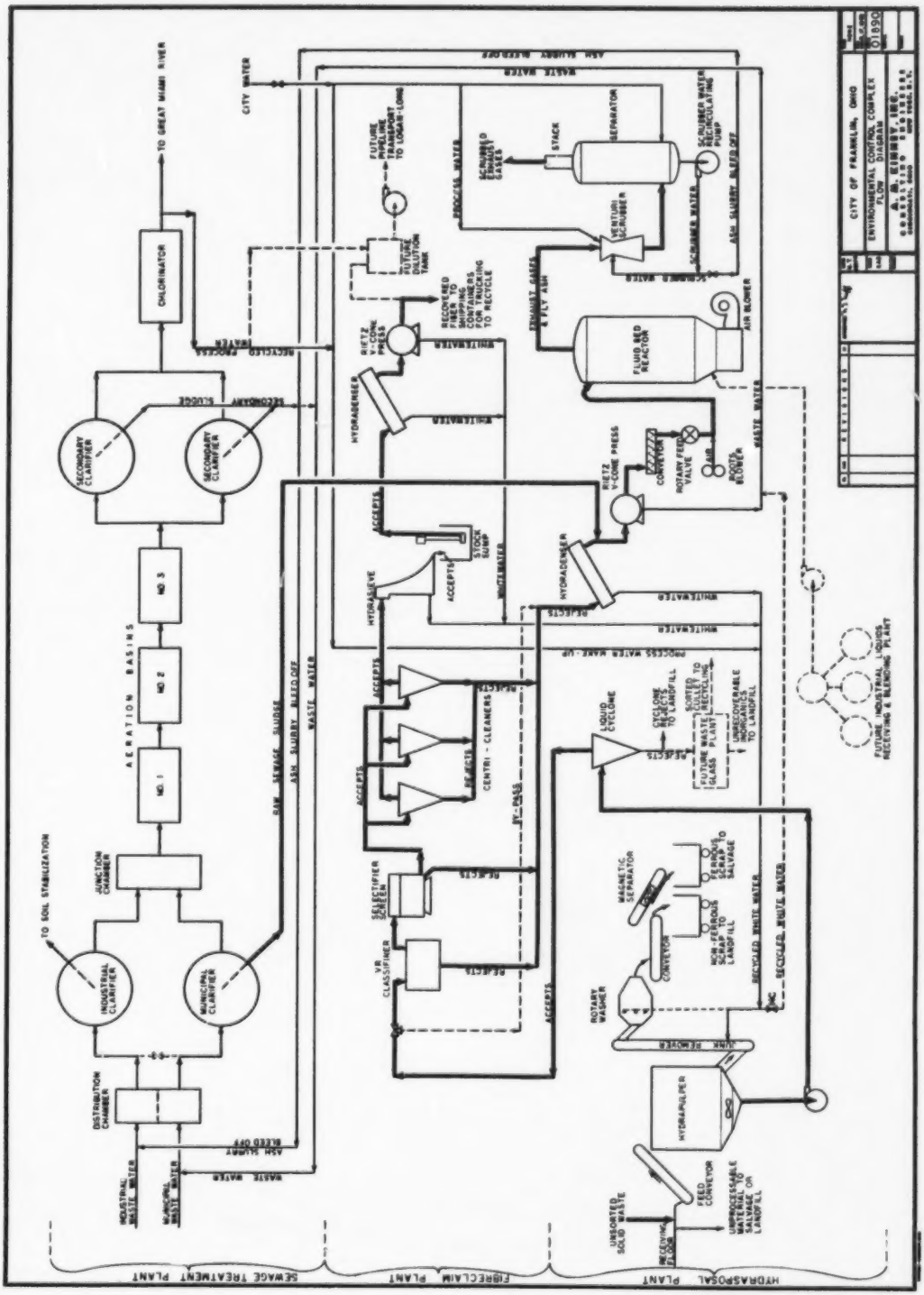

Figure 1. Environmental control complex flow diagram

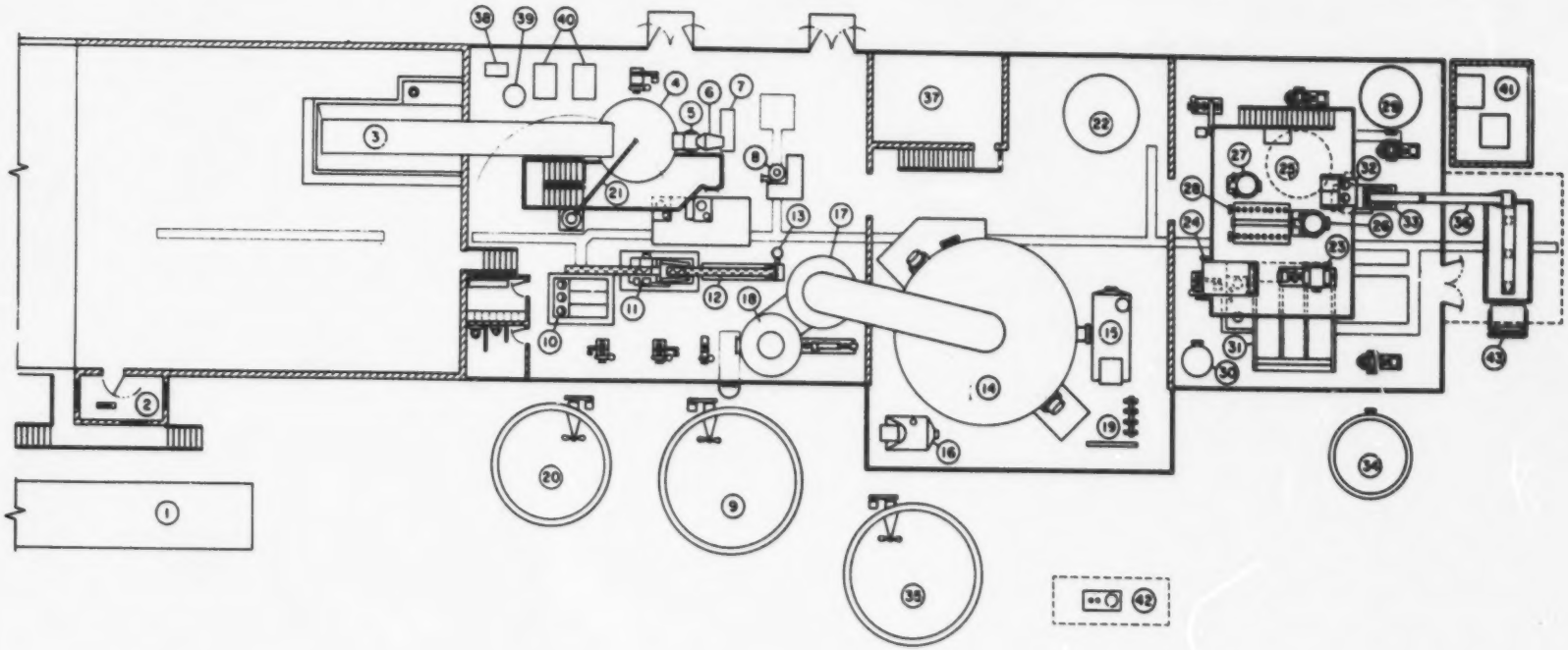

Figure 2. Plant layout

LEGEND

1 - SCALE
2 - SCALE OFFICE
3 - CONVEYOR
4 - HYDRAPULPER
5 - JUNK REMOVER
6 - JUNK WASHER
7 - MAGNETIC SEPARATOR
8 - LIQUID CYCLONE
9 - NON-RECOVERABLE ORGANICS STORAGE TANK
10 - HYDRADENSER
11 - CONE PRESS
12 - REACTOR FEED CONVEYOR
13 - PNEUMATIC FEED
14 - FLUID BED REACTOR
15 - FLUIDIZING AIR BLOWER
16 - PRE-HEAT BURNER BLOWER
17 - VENTURI SCRUBBER
18 - SEPARATOR
19 - FUEL OIL PUMPS
20 - WHITE WATER TANK
21 - CRANE
22 - FIBER RECOVERY STORAGE TANK
23 - VR CLASSIFINER
24 - GYRO-FLOTE
25 - SCREEN SUPPLY DILUTION TANK
26 - 24-P SELECTIFIER SCREEN
27 - 12-P SELECTIFIER SCREEN
28 - CENTRIFUGAL-CLEANERS
29 - CLEANER SUPPLY TANK
30 - REJECTS TANK
31 - FINES SCREEN
32 - HYDRADENSER
33 - CONE PRESS
34 - WHITE WATER TANK
35 - SLUDGE TANK
36 - TRUCK LOADING CONVEYOR
37 - CONTROL ROOM
38 - COMPRESSED AIR DRYER
39 - COMPRESSED AIR RECEIVER
40 - AIR COMPRESSORS
41 - SUB STATION
42 - FUEL OIL STORAGE
43 - TRUCK

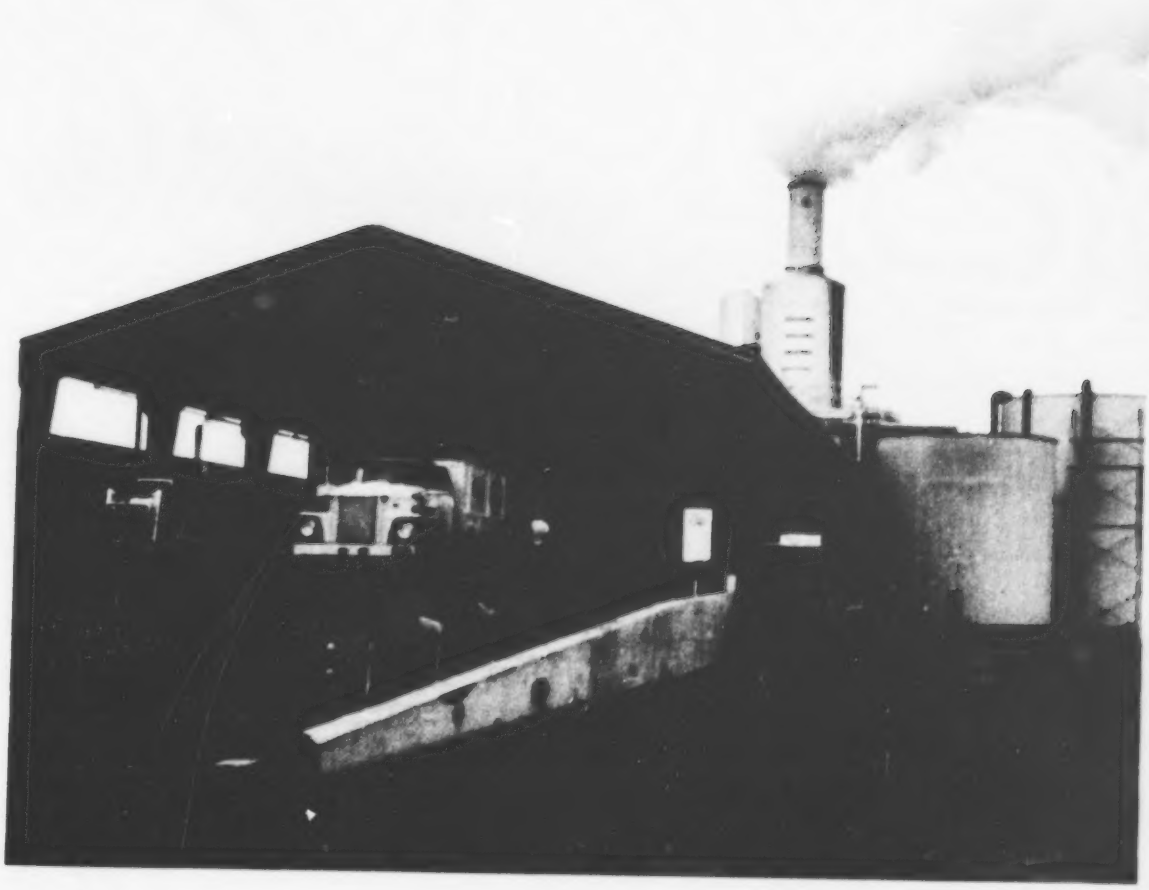

Figure 3. Receiving floor

ejected from the Hydrapulper through an opening in the side of the tub, and pass down a chute to a specially designed bucket elevator known as the junk remover. In this chute they receive a preliminary washing by the water which is being recycled back into the pulper. The junk remover discharges the materials into a rotating drum washer, where the washing action is continued. They are then conveyed under a magnetic separator where tin cans and other ferrous objects are separated for recycling. The nonferrous materials are collected for landfill burial.

The slurry is extracted from the Hydrapulper through 7/8 inch diameter holes in a perforated plate located beneath the rotor in the bottom of the tub. In addition to paper fiber, the slurry contains almost all of the organic content of the refuse, plus most of the glass, small pieces of metal, ceramics, and heavy plastics. To remove the inorganics, the slurry is pumped to the liquid cyclone, where the heavier materials are separated by centrifugal action. Since the end of the demonstration period a second cyclone has been installed in series with the original cyclone to increase the effectiveness of this operation.

The heavier materials pass into a chamber in the bottom of the liquid cyclones from which they are discharged into the liquid cyclone rejects conveyor and conveyed into hoppers for landfill disposal. The glass and aluminum recovery system will interface with the solid waste plant at the discharge of the liquid cyclone rejects conveyor.

2. Fibreclaim System. After nearly all the metals and glass have been removed for recycling, the slurry normally is pumped to the Fibreclaim process for extraction of paper fiber. A three-way valve in the liquid cyclone "accepts" piping permits the Fibreclaim system to be by-passed whenever it is

necessary, or desirable, to do so. In this process, the long paper-making fibers are mechanically separated from nonrecyclable coarse organics, such as rubber, textiles, leather, yard waste, high wet strength paper, paper coatings and fillers, paper fines, and very small pieces of glass, dirt, and sand.

a. Screening and Cleaning Subsystem. At the end of the demonstration period, the coarse contaminants were being removed in two stages of screening. The first stage was a Black Clawson VR Classifiner, in which the acceptable material was passed through a screen having 1/8 inch diameter openings. The second stage screen was a Selectifier screen having 1/16 inch diameter openings. This arrangement has since been modified.

The fine glass and dirt is removed by pumping the material accepted by the Selectifier screen through a battery of centrifugal cleaners. Separation of the organic fines from the longer, reusable fibers is accomplished by passing the slurry over an inclined, slotted fine screen known as a Hydrasieve, manufactured by the Bauer division of Combustion Engineering Company. The longer fibers are retained on the screen, while the fines pass through the 0.020 inch slots.

b. Fiber Dewatering and Re-Dilution Subsystem. Finally, the reclaimed long fibers are dewatered in two stages. The first stage is a Black Clawson Hydradenser, which is an inclined screw conveyor type thickener which removes most of the water. Additional water is removed by squeezing the partially dewatered pulp in a cone press manufactured by the Rietz Manufacturing Company. The pulp is delivered by screw conveyor either to a waiting truck or shipping container at 40 to 50 percent moisture or to a tank in which the fiber is rediluted with the sewage plant effluent water, and pumped directly to the Logan-Long Company, which buys them for use in making dry felt for asphalt roofing.

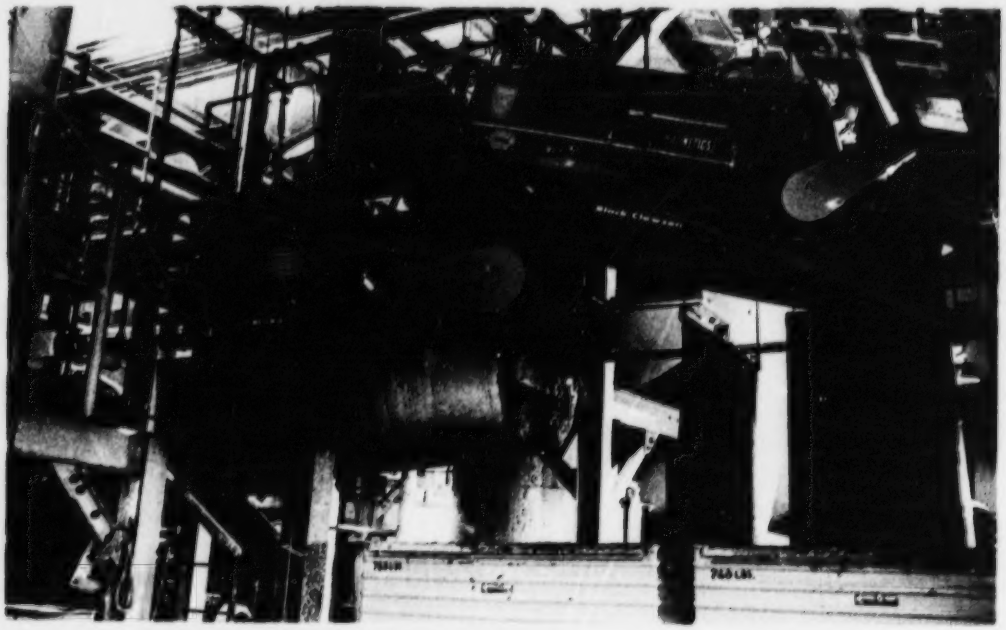

Fig. 5a—Magnetic Separator

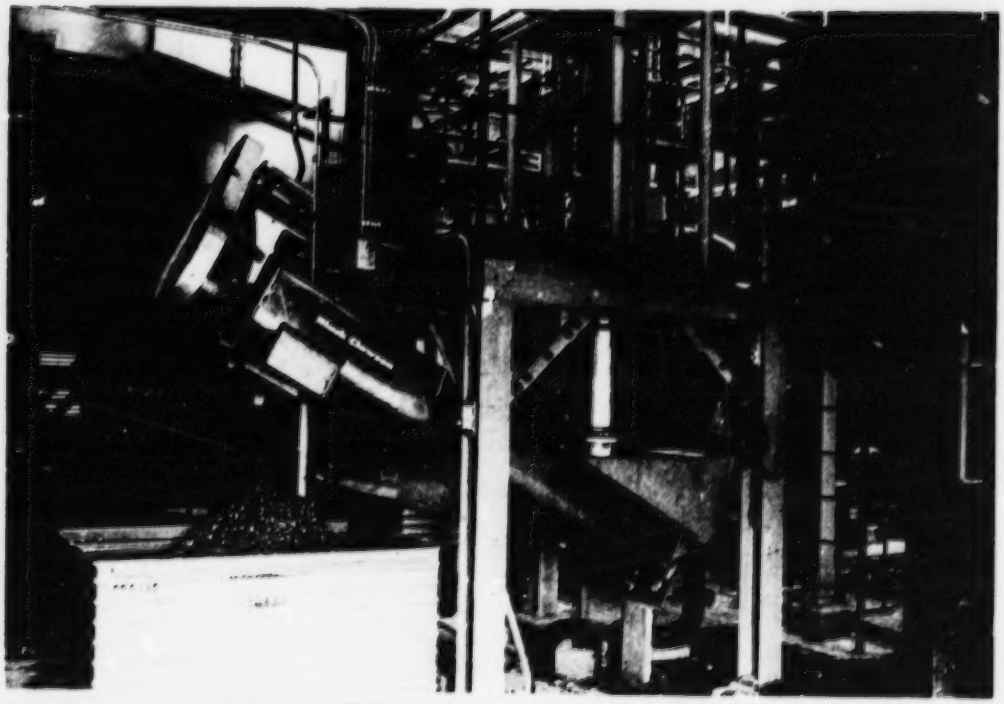

Fig. 5b—Liquid Cyclone

Figure 5. Magnetic separator and liquid cyclone

The unrecoverable organic rejects from the fiber recovery operations are combined and pumped to a storage tank. From the storage tank they are returned to the Hydrasposal system.

3. Hydrasposal System

a. Dewatering and Sludge Addition Subsystem. As the organic rejects are drawn from the storage tank at a desired rate they are dewatered to 40 percent solids content in two stages. An inclined screw thickener (Hydradenser) discharges to a Rietz cone press. The press discharges to a screw conveyor which breaks the dewatered cake into lumps 5/8 inch to 1-1/2 inches in size. Sludge from the adjoining sewage treatment plant is mixed with the organic rejects between the Hydradenser and the cone press and the combined mixture is dewatered without the aid of flocculating agents in the press. The combined wastes are then fed through a rotary feeder into a pneumatic conveyor system which delivers the material to the fluid bed reactor.

b. Fluid Bed Reactor Subsystem. The fluid bed reactor is a 25 foot inside diameter vertical cylindrical unit supplied by Dorr-Oliver, Inc. In this unit, room temperature air is blown by a 500 horsepower Spencer blower into a windbox at approximately 4-1/2 psig. The air flows upward through a perforated plate and gravel dispersal layer into a layer of sand, which it fluidizes. When starting up from a cold condition the fluidized bed is initially preheated by oil burners. After the fluidized sand reaches operating temperature of 1200 F to 1400 F, organic rejects are injected and burned. Continued injection of the organic rejects supplies sufficient heat value to continue combustion, so that no auxiliary fuel is required in normal operation. For shutdown periods in excess of 24 hours, small quantities of fuel oil are used to maintain bed temperature.

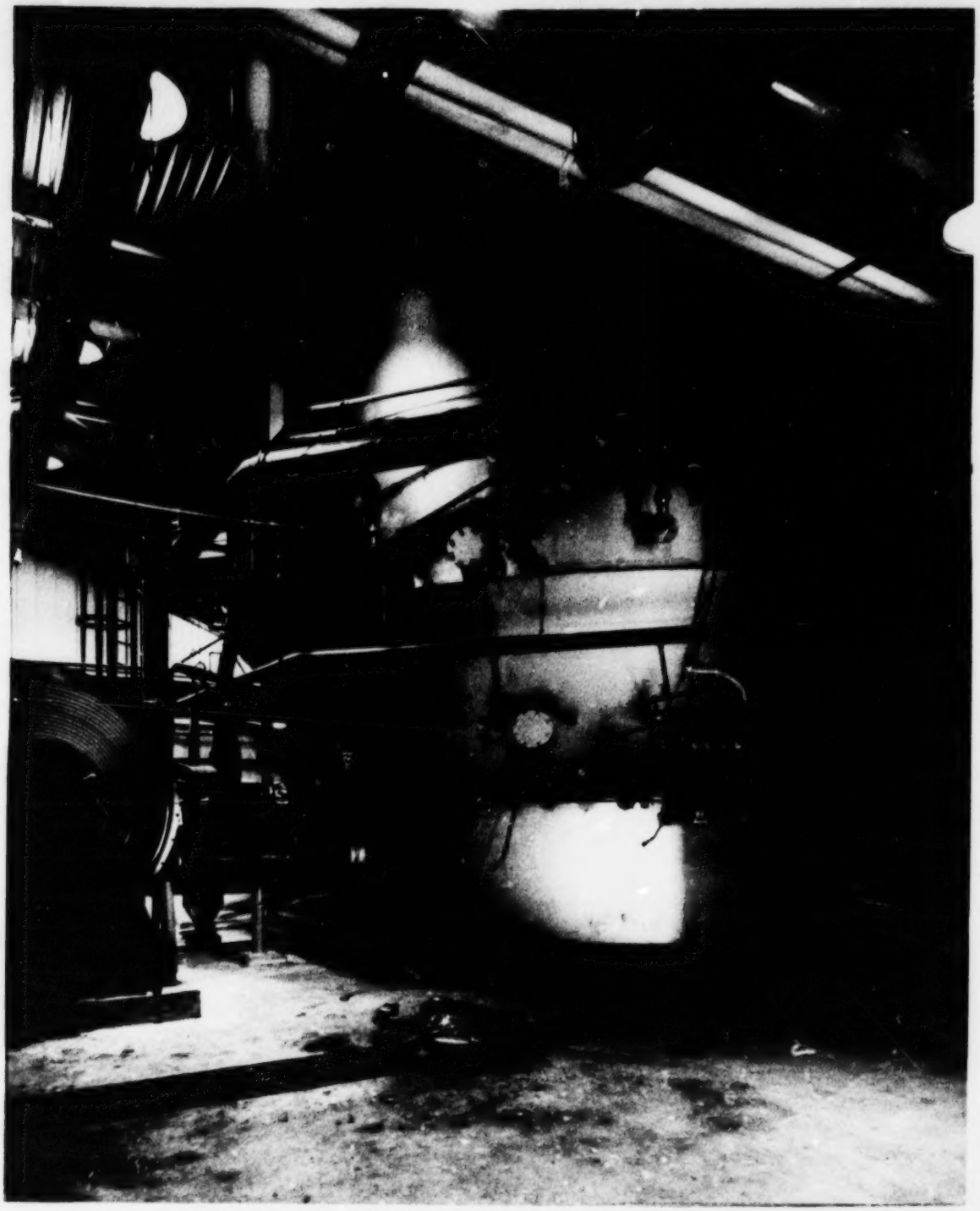

Figure 6. Fluid bed reactor

The exhaust gases are cleaned of particulate matter in a venturi scrubber, and are discharged through a gravity separator as a clean, nonpolluting, odorfree white plume. Ash-laden scrubber water is bled off to the sewage treatment plant, and is used as a settling agent in that process.

B. Description and Evaluation of Process Streams. The impact of the Franklin plant on the environment can be measured only by comparison of the inflows, which formerly were dumped or buried, with the outflows which are now either recycled, passed on to downstream treatment facilities, or emitted into the air. The material flows within the Hydrasposal and Fibreclaim processes are considered proprietary information by Black Clawson. This section of the report, therefore, is confined to the environmental impact concept. The material balance given in Table I, provides an overview of this analysis. Subsequent paragraphs give additional details of the various influent and effluent streams.

TABLE I

MATERIAL BALANCE

	Wet Weight (Tons)	Percent Moisture	Water (Tons)	Dry Solids (Tons)	Percent Total As Recovered
Weigh-In and Receiving					
Material In:					
Unsorted Solid Waste:	13,900	20*	2,800	11,100	80
Material Out:					
Unprocessible Material to Landfill:	220	20*	40	180	1.4
Material to Process:	13,680	20*	2,760	10,920	78.6
Total Material Out:	13,900	20	2,800	11,100	80.0
Hydrasposal and Fiber Recovery					
Material In:					
Solid Waste from Receiving:	13,680	20	2,760	10,920	78.6
Raw Sewage Sludge:	0	0	0	0	0
City Water:	144,100	100	144,100	0	-
Total Material In:	157,780	93	146,860	10,920	78.6
Material Out:					
Non-Ferrous Scrap to Landfill:	450	6	30	420	3.0
Ferrous Scrap Recovered:	930	20	190	740	5.3
Cyclone Rejects to Landfill:	1,390	15	210	1,180	8.5
Waste Water:	116,000	100	116,000	0	-
Fiber Recovered:	310	10	30	280	2.0
Organic Rejects to Reactor:	17,970	53	9,520	8,450*	60.8
Evaporated Water:	20,900*	100	20,900*	0	-
Total Material Out:	157,950	93	146,880	11,070	79.6
% Error:	0.1	0	.01	1.3	1.2

*No measured data for these items. Value extrapolated from other data.

The above material balance derived from raw data shows that errors in weight and flow measurements have averaged less than 4 percent over the period of this report. Since some input and output data were estimated this is considered acceptable accuracy.

1. Solid Waste Receipts. Between May 31, 1971, and August 20, 1972, a total of 13,856 tons of refuse were received at the plant. Of this amount, 13,633 tons were processed through the system.

Although categorization of wastes was requested, it has not been recorded. The plant operators, however, estimate that 85 to 90 percent of the receipts are from residential sources.

The tonnage received and not processed consisted primarily of large items which are not grindable by the Hydrapulper, such as vehicle tires, large steel drums, iron and wooden furniture, industrial pallets, automotive parts, major household appliances, building demolition waste, dead tree trunks, and lumber.

The Hydrapulper has proven able to process some items not originally considered as processable, such as dead small animals, aluminum lawn furniture, small appliances, television sets, light drums, and some industrial wastes.

Solid wastes are collected in the Franklin area by commercial haulers. Incoming refuse from these haulers is received from packer trucks, and open dump trucks. Individuals and small haulers bring refuse in pickup trucks, station wagons, rental trailers, and automobiles. Obviously processable loads are dumped on the receiving floor and pushed onto the feed conveyor by means of a front-end loader. One plant operator acts as weighmaster, receiving clerk, cashier, and loader operator. It is incumbent upon this operator to scan the incoming loads and the material being pushed onto the conveyor to extract unprocessable materials. During early operations, several instances occurred where ungrindable items were charged into the Hydrapulper with resulting downtime while the object was removed, and, if necessary, repairs were made to the Hydrapulper. When these materials

are spotted, they are pulled out, set aside, and periodically sold as scrap to a junk dealer. Unsaleable items must be landfilled, but these amount to only about 1-1/2 percent of the tonnage received. A design change was made which virtually eliminated Hydrapulper downtime resulting from damage by this type of material.

2. Junk Remover Rejects. Of the tonnage processed, approximately 10 percent is ejected by centrifugal action through the junk chute of the Hydrapulper into the junk remover.

The magnetizable, or ferrous, fraction averages 67-1/2 percent of the junk remover rejects, or 6.7 percent of the total refuse received. This consists mostly of cans, but also contains bottle tops, spark plugs, nails, bolts, and an infinite variety of unrecognizable pieces. This material is dumped into detachable truck bodies in which it is hauled several times a week to a nearby steel company (Armco) which pays the equivalent price of No. 2 bundles (presently $13.30 per short ton) for it.

No further recycling process is immediately contemplated for the nonmagnetizable rejects. These rejects average 3.2 percent of the refuse tonnage received, and are disposed of in the nearby plant landfill.

Typical analyses of the junk remover reject streams are as follows:

Sixty-eight percent of junk remover rejects are collected by the magnetic separator. Approximately 75 percent of this fraction is all-steel cans and steel cans with aluminum tops, while the remaining 25 percent usually is spark plugs, nuts, bolts, wire, and automobile and appliance parts. Of the 32 percent of the junk remover rejects not collected by the magnetic separator approximately 13 percent is nonferrous metal, 1 percent is ferrous metal missed by the separator, about 37 percent is miscellaneous objects such as rubber,

heavy plastics, stones, and large pieces of glass, and approximately 49 percent is organic materials and water.

3. Liquid Cyclone Rejects. Approximately 10 percent, by weight, of the total refuse received is separated by the liquid cyclone.

An average of analyses of the rejects from the single liquid cyclone used during the demonstration period, shows this stream consists of:

Description	Percent (Dry Basis)	
Clear glass	37.9	
Green glass	4.2	
Amber glass	18.1	60.2
Magnetic metals	3.6	
Aluminum	2.3	
Other metals	0.6	6.5
Large stones (larger than No. 4 mesh)		4.8
Loss on ignition		8.3
Miscellaneous materials (plastics, rubber, etc.)		20.2
Total		100.0

The waste glass plant now under construction will receive its input from the liquid cyclone discharge conveyor. At present, however, this material, along with nonferrous junk remover rejects and the unsaleable, unprocessable material, is buried in the plant landfill. During the demonstration period, the cyclone rejects contained a higher percentage of adherent organic material than was originally anticipated. The second cyclone has helped to reduce the amount of this material, but the waste glass plant equipment train will include washing and screening operations to ensure its removal, before color sorting the glass. These contaminants will be returned to the main plant for burning.

Figure 13 in Volume II shows the trends in analyses of cyclone rejects during the report period.

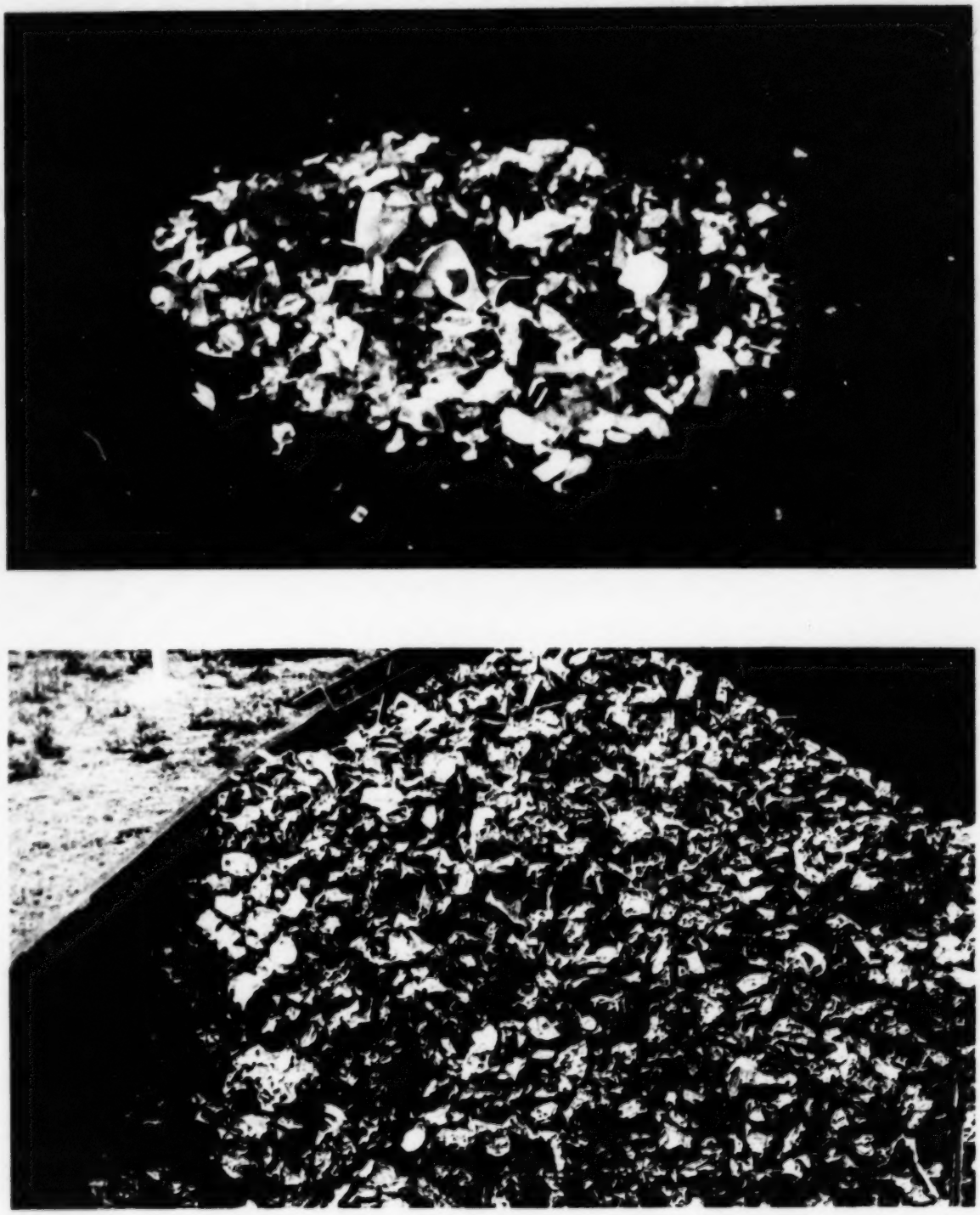

Figure 7. Cyclone rejects and junk remover rejects

4. Recovered Fiber. Fiber recovery operation began during July 1971, and continued through Aug. 28, 1971. During this period 76.3 tons of fiber (air dried basis) were produced, which was sold to the Logan-Long Company of Franklin, Ohio, manufacturers of roofing products.

On Aug. 28, 1971, fiber production for Logan-Long Company was stopped because of operating problems on their paper machine. Between Sep. 1 and Sep. 15, 1971, Logan-Long Company evaluated the performance of their machine using no reclaimed fiber. During this same period, The Black Clawson Company and Logan-Long Company conducted laboratory investigations into the cause of the problems. The results of these investigations are discussed in Subsection C of this section under the heading of "Operating Problems and Process Improvements."

Fiber recovery operations were resumed in September and October to produce fiber for a series of experimental papermaking tests being made by the St. Regis Paper Company, and were again resumed in November for Logan-Long Company after both they and The Black Clawson Company made process changes which enabled Logan-Long to use the recycled fiber.

The quality of recycled fiber, when processed in a paperboard mill equipped to eliminate lipids and fines, is reported to be good. No analytical data on the experimental paper and board manufactured from the recovered fiber have been reported. The Logan-Long Company has reported that the fiber is the equivalent of the composite of the corrugated board, old newsprint, and mixed paper currently used by them in the production of roofing felt.

The commercial viability of the fiber recovery process depends not only on the physical usefulness of the fiber, but also on the financial return which would result from the additional capital required for this adjunct to the

Hydrasposal system. The Black Clawson Company reported for the "Interim Report," that the oven-dried fiber yield at the Franklin plant was 5 to 7.6 percent of the refuse tonnage received at the plant, compared to the 18 percent yield indicated by the Middletown pilot plant operation and several experimental runs at Franklin. For this Final Report, The Black Clawson Company stated the yield was 1 percent of the total refuse received. Since the end of the demonstration period, several modifications to the system have been made which have increased the yield to a reported 14 percent of the total tonnage received. The cost figures obtained for the Interim Report showed the Fiber Recovery operation increased the operating deficit. No separate cost figures for the Fibreclaim system were made available for the Final Report.

The tonnage of fiber produced during the report period is shown in Figure 3 in Volume II.

5. Waste Water. Now that sewage sludge is being dewatered and burned in the fluid bed reactor, part of the total waste water discharge is that which has conveyed the sludge to the solid waste plant. This water is segregated to prevent contamination of the plant process water with untreated sewage water.

Process water is constantly withdrawn from the system to reduce the level of total and dissolved solids in the process water. This is replaced with fresh water makeup. During the period of this report, this makeup was supplied entirely from City water but the present operation uses treated effluent water from the sewage treatment plant.

An average analysis of the waste water is as follows:

pH	5.6
Five day BOD	3,973 mg/liter
Suspended solids	5,119 mg/liter
Total dissolved solids	3,739 mg/liter
Settleable solids	5,675 mg/liter

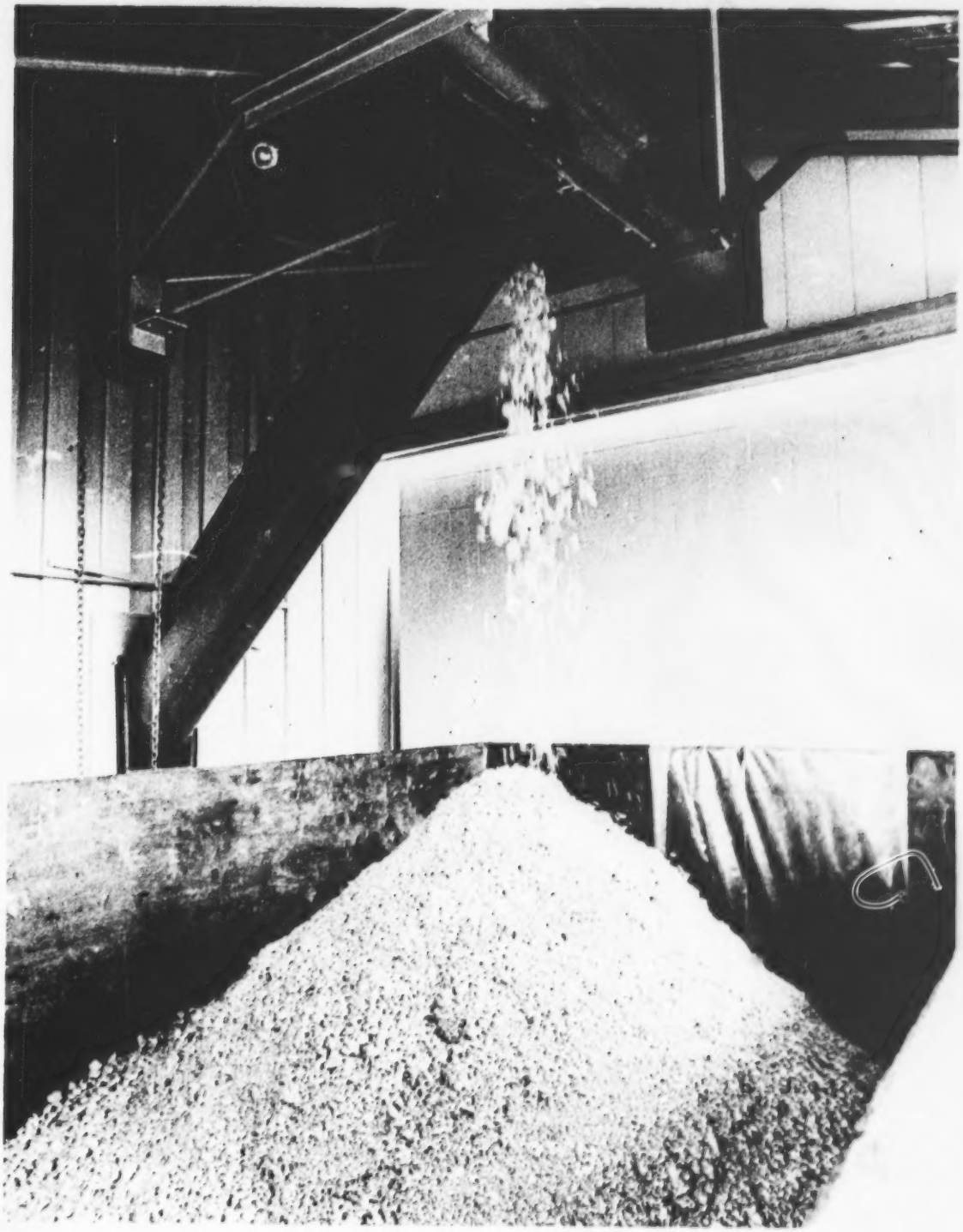

Figure 8. Paper fiber being loaded for shipment

Temporarily, the waste water was piped to an aeration basin installed by MCD to serve until the sewage treatment plant was completed. The treated water was then discharged to ground absorption. This water is now piped directly to the sewage treatment plant.

Detailed analyses of the various plant waters are given in Volume II.

6. Sewage Sludge. Because the area waste water treatment plant built by the MCD had not been completed, no sewage sludge was burned during the report period.

7. Ash Slurry. Approximately 35 gpm of ash slurry is bled from the scrubber-separator water recirculating system. This quantity can be varied to limit the amount of total solids in this system, but it is now run at a constant rate because of failure of the flowmeter supplied with the scrubber.

An average analysis of the ash slurry water is as follows:

pH	8.9
Total solids	14,715 mg/liter
Suspended solids	12,438 mg/liter
Dissolved solids	2,732 mg/liter
Settleable solids	9,941 mg/liter
Total volatile solids	1,483 mg/liter

Variations in the chemical and physical properties of the ash slurry are shown in the Analytical Data Summary in Section VI-B. Before the MCD sewage treatment plant was completed, the ash slurry was temporarily discharged to surface drainage. When the sewage treatment plant became operational, this slurry was then connected to the industrial primary clarifier where it is now used as a settling agent. (See Figure 1).

8. Stack Gases. The products of combustion from the fluid bed reactor are conveyed through a downflow venturi scrubber, then up through a gravity separator column before being discharged to atmosphere.

From Dec. 28, 1971, through Jan. 4, 1972, a field crew from Environmental Sciences, Inc., of Pittsburgh, Pennsylvania, performed a series of three tests covering simultaneous sampling of the emissions from the fluid bed reactor and the emissions from the scrubber serving the reactor. The data taken consisted of the collection and analysis of the particulate and gaseous emissions in the stack gases. Also during each test, samples of the inlet and outlet scrubber water, and of organic rejects fed to the reactor were collected, so that a complete material balance could be performed on the entire system.

The purpose of the testing program was to determine the air pollution emissions from the fluid bed reactor in order to certify to the City of Franklin and to the State of Ohio the quantity and nature of the air pollutants being emitted from the process. Tests of the fluid bed reactor and the venturi scrubber were also needed by A. M. Kinney, Inc., to prepare this comprehensive evaluation of the treatment process. The testing program permitted the determination of the emissions from the fluid bed reactor when operating at normal operating capacity at steady state, as well as the determination of the collection efficiency of the venturi scrubber serving the fluidized bed reactor.

Based upon the results of the three tests performed on the inlet and outlet of the scrubber, the following average results were reported by Environmental Sciences, Inc.

Scrubber dry solids removal efficiency	98.8 percent
Scrubber condensables removal efficiency	23.5 percent
Solid particulate loss on ignition (900 C)	3.3 percent

Parameter	Inlet	Outlet
Grain loadings - grains per standard dry cu ft (SDCF) at 12 percent carbon dioxide	4.5	0.076
Grain loadings - grains per SDCF - acutal reading	2.542	0.043
Condensables - percent	1.0	45.5
Particulate flow - lb/hr	358	6.11
Volumetric flow rate SDCF per minute	16,500	--
Gas temperature - F	1400	190
Water - percent	5.5	34.1
Sulfur dioxide--parts per million (ppm)	45	less than 7
Nitrogen oxides--ppm	143	125
Aldehydes	none	none
Hydrocarbons	none	none
Carbon monoxide	trace	trace
Chlorides--lb/hr	4.7	0.43

The data given above show that the effluent from the fluid bed reactor contains only a trace of combustible material, either as gases or solids. These results indicate that the reactor is an efficient thermal oxidizing system.

The venturi scrubber and mist separator remove about 98 percent of the dry and condensable particulate. Since the scrubber system operates at a differential of only 7 inches of water, its performance is considered excellent.

The impinger water was very acidic and analysis indicated unmeasurably small amounts of nitrates and fluorides, with most of the soluble, condensable material in the form of sulfates and chlorides. The scrubber water is only slightly acidic (pH approximately 6.0) and a chemical analysis indicated large amounts of solids and dissolved particulates, with high quantities of sulfate and chlorides, and only minor amounts of other ions.

The quality and quantity of the particulate and gases theoretically emitted from the reactor and the measured quantities of material picked up by the scrubber water system did not balance well with the measured concentrations of pollutants in the stack gas due to errors involved in: (1) obtaining a representative sample of scrubber water; (2) estimating scrubber water flows and refuse fuel consumption; (3) an accurate fuel analysis; (4) not chemically analyzing the solid particulate collected during the test, and (5) miscellaneous problems that could be isolated and solved only by extensive research.

These tests show that the emissions from the scrubber are below the limit of 0.1 grain per standard dry cubic foot of gas flow (corrected to 12 percent carbon dioxide) set by the process equipment specifications, which were based on Federal guideline specifications in effect at that time.

Regulations adopted by the State of Ohio Air Pollution Control Board, on Jan. 28, 1972, with an effective date of Feb. 15, 1972, limit dust emissions from incinerators to 0.1 pounds of particulate matter per 100 pounds of dry

combustible refuse charged, as determined by ASME power test Code PTC-27 when operating at the manufacturer's maximum rating. Converting the results of these tests to this basis, shows an average emission rate of 0.07 pounds per 100 pounds of refuse burned in the reactor.

In an independent test conducted by Dorr-Oliver, Inc., in April 1972, results showed an emission rate of 0.09 pounds per 100 pounds of refuse burned. The increase is believed to be due to the fact that the venturi cone had been tipped over. Since that test, the venturi cone has been replaced.

9. Organic Rejects. Although it is not an external stream, the fuel feed to the fluid bed reactor also was monitored during the evaluation period in order to gather operating data on this key element of the Hydrasposal system. The physical characteristics of the reactor sand bed and the ash from the reactor fuel are also analyzed at monthly intervals.

The average analyses of the organic rejects are as follows:

Ultimate Analysis	Percent
Moisture	52.26
Carbon	24.20
Hydrogen	3.14
Oxygen	15.55
Nitrogen	0.07
Sulfur	0.10
Ash	4.88

Proximate Analysis	Percent
Moisture	52.26
Volatile	37.82
Ash	4.88
Fixed carbon	5.01

Heating value (oven dry basis) 7,454 Btu per pound

Figure 4 in Volume II illustrates the variations in proximate analyses of the reactor fuel. Individual tests are tabulated and summarized in Appendix A.

10. Auxiliary Fuel. No. 2 commercial fuel oil is used to preheat the bed sand in the fluid bed reactor in order to bring it up to minimum operating temperature. When the bed reaches this temperature, feeding the dewatered organic rejects is begun, and, under normal operation, all of the rejects burn without support fuel. Under unusual or upset conditions, such as periods of intermittent organic reject feeding, it has been necessary to fire supplementary fuel through oil guns located within the static bed level to maintain minimum bed temperature. During the period of this report a total of 44,770 gallons of fuel oil were used, including approximately 4,600 gallons used during a period when organic rejects were drawn off intermittently for test purposes, thus interrupting continuous feed to the reactor.

11. City Water. During the demonstration period covered by this report, City water was used as the sole source of makeup water to the system. Now that the sewage treatment plant has been completed, its effluent is being recycled for use as process water. Usage of City water is being continued, in the venturi scrubber sprays and as seal water.

Actual quantities of City water used were recorded for only 12 weeks of the evaluation period due to extremely erratic and unreliable operation of the City water meter. Based on such of those readings as were deemed reliable, City water usage was estimated on a weekly basis to be a total of 34,598,200 gallons for the entire evaluation period, or an average of 2,537 gallons per ton of refuse processed. This is equivalent of 263 gpm.

Similarly, waste water discharged was estimated to be 27,855,000 gallons for the entire evaluation period. This results in an average of 2,043 gallons per ton of refuse processed, or 212 gpm.

12. Electric Power. Electric power service to the plant is supplied by The Cincinnati Gas & Electric Company, through a single 2,000 kilovolt-ampere (kva) transformer and meter serving both the Hydrasposal and Fibreclaim systems. A separate temporary connection was installed to serve the floating aerator in the temporary waste water treatment basin. The sewage treatment plant is served by its own transformer and meter.

Power consumption for the report period was a total of 2,390,400 kilowatt-hours (kwh). No measurement of the division between Hydrasposal and Fibreclaim systems is available.

The unit consumption of electric power during report period is computed as follows:

2,390,400 kwh consumed, divided by the 13,633 tons processed, equals 175 kwh per ton of refuse. Because this quantity includes the start-up period it is to be considered as order-of-magnitude only.

13. Rejects to Landfill. The three streams which go to landfill are summarized as follows:

a. Unprocessable Refuse Received. Consists of large or heavy ungrindable or unfriable items. This fraction averages approximately 0.66 tons per day or 1-1/2 percent (by weight) of refuse received.

b. Nonferrous Junk Remover Rejects. Consists of smaller ungrindable or unfriable materials. This fraction averages approximately 1.45 tons per day, or 3.2 percent (by weight) of the refuse received.

c. Liquid Cyclone Rejects. Consists of inorganic rejects, 3/4 inch and smaller, which have passed through the extractor plate of the Hydrapulper. This stream contained an average of 8-1/2 percent putrescible organics with the single cyclone used during the demonstration period.

All of the cyclone rejects, which now go to landfill, average approximately 10 percent (by weight) of the refuse received.

In the summer of 1973, this stream will be diverted to the waste glass recovery system, where the glass and aluminum between 1/8 inch and 3/4 inch will be recovered for recycling. The remaining undersize and oversize material, stones, plastics, and metals will continue to go to landfill, but the putrescible organic portion will be returned to the Hydrasposal system for incineration in its fluid bed reactor.

The total of reject streams going to landfill during the report period averaged 15 percent of the tonnage received. No total measurement of volume to landfill was made, but this fraction is estimated to be less than 5 percent of the total volume received at this plant.

Figure 2 in Volume II shows the variations in quantities and constituents of the material taken to the plant landfill. Quantities are reported by the plant operators on an oven-dried basis, in order to eliminate variations in actual tonnage due to varying moisture contents.

C. Operating Problems and Process Improvements. While the physical data in this report are concerned primarily with quantitative and qualitative analysis of external process streams, the overall effectiveness of the Franklin demonstration plant is dependent on its internal operation.

The problems which have affected overall plant operation, and the improvements which have been made, are thus an integral part of this analysis.

1. Refuse Receiving. For economy reasons, the refuse receiving area was designed as an open-ended, high-walled shed. The basis for computation of receiving floor space was that the entire area, except for walking aisle space, would be used for receipts. This has proved impractical for operation of the front-end loader. As a result, when a number of trucks arrive within a short time span, it is necessary to accumulate the refuse on the ramp leading to the receiving floor until the peak is worked off. Although this has been unsightly, and outside operation of the front-end loader during inclement weather is inconvenient, the plant operators believe that no remedial action is economically justifiable.

Another operating problem was the presence of maggots in the apron conveyor pit and sump, on the receiving floor, and on the operating floor. This problem was worst during the first summer of operation, but it has been controlled since then by the regular use of insecticides.

A continuing problem is tire wear on the front-end loader. The operating conditions for this machine result in the need for replacement of the tires approximately every 6 months despite a switch to solid heavy-duty industrial tires.

To compensate for maintenance downtime on the front-end loader, the plant service truck was purchased with a snowplow blade, which permits its use in pushing refuse onto the conveyor.

2. Hydrasposal System.

a. Hydrapulper.

(1) It was found in initial operation the apron conveyor caused large quantities of dust and dirt to fall out onto equipment and personnel below it, and that the Hydrapulper was splashing dirty water over the floor and visitors. Therefore, a fiber glass cover was fitted over the Hydrapulper and conveyor, equipped with access doors and a monorail for access to the pulper. Rapid access is needed in order to remove ungrindable materials and to work on the rotor.

(2) A high maintenance item is replacement of the swing hammers on the rotor of the Hydrapulper. During the report period, life of the hammers was reported to be about 300 operating hours, and replacement time was reported to be approximately one hour. Development work has improved the effectiveness and service life of the hammers.

(3) Retrieval of unprocessable material that inadvertently entered the Hydrapulper, and repair of damage caused by it, caused some minor service interruptions during early operating periods. A design change to the Hydrapulper has apparently corrected the damage problem, and operators have learned to watch the material on the conveyor more closely. Outages of this type have ranged from 1/2 hour to 2 days.

(4) Excessive vibration of the Hydrapulper occurred during the initial operation period. The addition of heavy crossbracing to the pulper supporting structure has largely eliminated this problem.

b. The Hydrapulper dump pump has been a relatively high maintenance problem, primarily due to the highly abrasive material it handles. The pump casing and other wetted parts have been subject to repeated replacement.

c. Hydradensers. The lack of consistent performance by the solid waste plant Hydradensers (dewatering screws) was the subject of continuing developmental work. Their erratic water removal characteristics and the need for frequent adjustment has had an adverse effect on experimental work on the burning of organic rejects, and on the plant maintenance costs. Design changes have now corrected this situation.

d. Fluid Bed Reactor.

(1) The following three problems related to the sand bed of the reactor have occurred during this report period:

A gradual attrition of the sand in the fluid bed, caused by the mechanical agitation of the sand, has resulted in fine particles of silica being carried over into the scrubber-separator and the buildup of silicon-rich scale in the separator. This was manifested as stones which caused some damage to the scrubber water pump, until the operators began to inject a dispersion agent into the system. This chemical, similar to that used in boiler water treatment, tends to keep the scale soft and in suspension in the scrubber water.

A gradual agglomeration of the sand and its retention of mineral ash and glass particles, resulted in an increase in the size of the bed sand particles. This became evident from sieve analyses and increases in fluidizing air blower horsepower requirements. In February 1972, it became necessary to replace the entire sand bed, because of accumulation of large masses of agglomerated sand. The operating contractor has instituted a program of periodic replacement of the sand bed, and has reduced the maximum operating temperature limit.

Slag tends to build up at the top of the reactor chamber and in the cross-over flue from the reactor to the venturi scrubber. In some places deposit had reduced the flow area of this duct by more than half. This had been attributed to excessive free-board temperatures causing low-melting-point ash to deposit in the duct. Consequently, the point of fuel feed to the reactor has been lowered, and the plant operators have reset the controls to maintain a 1,400 F maximum free-board temperature.

(2) During early operations the rotary feeder which passes the pulped organic rejects into the pneumatic feeder supply to the fluid bed reactor repeatedly plugged and constantly limited the firing rate. To overcome this problem, this feeder was replaced with one of a different design with the result that plant throughput capacity has been noticeably increased.

e. Miscellaneous. A number of relatively minor additions and corrections were made during the demonstration period, to improve the operation of the Hydrasposal process. Among these have been modifications to the junk remover to eliminate excessive water carryover, relocating access doors in the junk remover, changes in instrumentation and control, and provision of an additional access door and sand removal spout in the fluid bed reactor. In addition, the original 1,500 kva power transformer was replaced with a 2,000 kva transformer in order to provide the additional electrical power capacity required for the waste glass recovery plant and for changes in the fiber recovery process.

f. Plant Design Limitations. The requirement of minimal first cost placed limitations on the design of the Franklin plant which have resulted in

several operating problems that cannot be economically corrected. Among those which should be considered in the design of future plants are:

In addition to the previously mentioned space problem in the receiving area, limited space in the Hydrasposal area has resulted in a crowded equipment arrangement, which in turn makes difficult access to some areas for maintenance and housekeeping.

A somewhat annoying operating problem is the excessive amount of process water spillage on the operating floor in the Hydrasposal area. While the amount of water on the floor may not be considered excessive by contemporary paper mill standards, it is excessive from both a housekeeping and sanitary standpoint. In future designs, consideration should be given to improving drainage in this area.

Another problem at the Franklin plant for which there appears to be no simple solution is the high noise level around the Hydrapulper. While future plants may be able to overcome this problem, the Franklin plant layout precludes construction of sound-attenuating walls. However, it should be noted that the operator's station at Franklin is in the control room, where the sound level is below the 80 dbA continuous occupancy limits of the Occupational Safety and Health Act, and that occupancy of areas having sound levels higher than 80 dbA is abnormal and for a relatively short time.

3. Fibreclaim System.

a. Fiber Quality. As stated heretofore, fiber recovery production for the Logan-Long Company was stopped on Aug. 28, 1971, because of problems experienced on their paper machine when using the recycled fiber from the solid waste plant. The Black Clawson Company later reported that tests made by

Logan-Long Company with their paper machine, and tests made by The Black Clawson Company in their laboratory indicated the cause of the problem was the concentration of lipids and fines which occurred when the recirculating process water system, (known in the pulp and paper industry as the "white water system"), was closed up; i.e., when a higher percentage of the total white water flow was recirculated, a lesser amount bled off to waste, a therefore less "fresh water" added to the system. This action caused an increased amount of lipids and fines to be present and to adhere to the fiber.

In the papermaking operation, as at Logan-Long Company, water is removed from the newly formed sheet by pressing it out through a series of wringers, called press rolls. The sheet of paper is supported at the press rolls by a very porous woolen blanket, which also serves as a medium whereby the pressed-out water may be removed; i.e., the water leaves through the pores in the blanket. The fines and lipids apparently fill up these pores, resulting in reduced life of the blankets.

The condition was corrected temporarily by employing an excessive amount of fresh water in the fiber recovery operation, with equivalent increased bleed-off from the system to reduce the equilibrium level of fines and lipids in the white water, and by installation of a high pressure shower to clean the blanket on the Logan-Long Company paper machine. Since that time, The Black Clawson Company has installed a flotation clarifier in the white water recycling system to reduce this contamination. Logan-Long now regularly uses the recovered fiber in their production process.

b. Fiber Yield. Primarily due to problems associated with scaling up from pilot plant to full-scale commercial operation, the yield of recovered fiber has been substantially below expectations.

The screening system, which selectively sorts out the recyclable long fibers, was sized according to secondary fiber paper mill standards. The screens were found to be inadequate due to the much higher quantities of plastics, rubber, etc., present in the solid waste slurry. As a result, the fiber recovery department could not operate at the capacity of the balance of the plant. Several experimental runs were made at reduced overall capacity, and the anticipated yield of more than 20 percent on an air-dried (10 percent moisture) basis, was realized. Additional screening capacity was installed and improvements made to the reject screening system so that yields now are estimated by The Black Clawson Company to be about 14 percent of the tonnage received during the period when the plant is in operation.

SECTION IV - ECONOMIC ANALYSIS

A. Construction Costs. The following construction cost report, prepared by A. M. Kinney, Inc., is based on value of the process equipment contract at the end of the demonstration period, and the final contract values for the construction contracts. The final value given for the mechanical contract includes $3,230 for installing additional nozzles and temporary scaffolding to make the stack gas analysis. The process equipment contract was kept open after the end of the demonstration period to cover process changes in the Fibreclaim System.

The general construction work, including site development, grading, foundations, structural and miscellaneous steel, building work, paving, painting, and landscaping, was done by the Monarch Construction Company of Cincinnati, Ohio.

The mechanical construction, including installation of all Owner-furnished process equipment, contractor-furnished mechanical equipment, piping, ductwork, instrumentation heating, ventilating, and plumbing was done by Hughes-Bechtol, Inc., of Dayton, Ohio.

Electrical construction work, including furnishing and installing temporary construction power and all lighting, electrical conduit, wire, fixtures and equipment, grounding system, electrical controls, and instrumentation was done by the Gustav Hirsch Organization, Inc., of Columbus, Ohio.

Sprinkler construction work including furnishing and installing all materials for the sprinkler system in the receiving area, was done by the Cincinnati Sprinkler Company of Cincinnati, Ohio.

The sound system for the project included furnishing of equipment for an industrial page-party phone and speaker system. This was done by J. W. Thompson Company of Middletown, Ohio. Installation was under the electrical contract.

Process equipment includes the Hydrapulper, liquid cyclone, tanks, pumps, fluid bed reactor, venturi scrubber and gravity separator, screens, process instruments, and controls. This was supplied by the Shartle-Pandia Division of The Black Clawson Company of Middletown, Ohio, who also supplied the process design information, including flow rates, pressures, consistencies, and equipment dimensions and weights. The only breakdown of this contract available is between the solid waste disposal plant and the fiber recovery plant. No details of this breakdown, such as the cost of individual items of equipment, cost of subcontracted systems (such as the reactor, scrubber and separator), or the cost of process engineering have been released by The Black Clawson Company, so that the detailed breakdown into operation centers, given in the following pages, represents the authors' estimate of these costs.

The miscellaneous equipment listed in the General Cost Summary includes such items as the plant service truck, forklift truck, front-end loader, drop-bottom hoppers, cash register and office furniture. The items were purchased from several equipment suppliers on the basis of competitive, public bidding.

Construction costs are shown in the General Cost Summary on the following pages. The breakdown of construction costs by operation centers represents estimated cost allocations, based on a detailed review of contractor's payment requests for various portions of the work, such as structural concrete, process piping, etc.

CITY OF FRANKLIN, OHIO

SOLID WASTE AND FIBER RECOVERY PLANT

COST ANALYSIS

GENERAL CONSTRUCTION COST SUMMARY

ACTUAL COSTS

Item	City Unreimbursed	Solid Waste Plant		
		Federal Share	City Share	Total
Process equipment	$ 2,250.00	$ 506,564.67	$ 253,282.33	$ 759,847.00
Construction				
General construction	---	$ 152,260.34	$ 76,130.16	$ 228,390.50
Mechanical construction	$ 779.00	179,075.33	89,537.67	268,613.00
Electrical construction	--	66,765.15	33,382.57	100,147.72
Fire protection	--	2,900.00	1,450.00	4,350.00
Sound system	--	445.11	222.55	667.66
Sub-total	$ 779.00	$ 401,445.93	$ 200,722.95	$ 602,168.88
Miscellaneous equipment	--	24,771.23	12,385.59	37,156.82
Present construction and equipment contracts	$ 3,029.00	$ 932,781.83	$ 466,390.87	$1,399,172.70
Engineering (as of Dec. 31, 1971)	--	81,994.12	40,997.06	122,991.18
Total	$ 3,029.00	$1,014,775.95	$507,387.93	$1,522,163.88

Fiber Recovery Plant			General Site Improvements	
Federal Share	Black Clawson Share	Total	Miami Conservancy District Share	Combined Totals
$ 121,651.33	$ 60,825.67	$ 182,477.00	$ --	$ 944,574.00
$ 48,346.67	$ 24,173.33	$ 72,520.00	$ 3,465.50	$ 304,376.00
65,317.99	32,659.01	97,977.00	6,973.00	374,342.00
31,082.58	15,541.28	46,623.86	--	146,771.58
--	--	--	--	4,350.00
--	--	--	--	677.66
$ 144,747.24	$ 72,373.62	$ 217,120.86	$ 10,438.50	$ 830,507.24
1,663.20	831.60	2,494.80	--	39,651.62
$ 268,061.77	$ 134,030.89	$ 402,092.66	$ 10,438.50	$1,814,732.86
--	41,138.55	41,138.55	--	164,129.73
$ 268,061.77	$ 175,169.44	$ 443,231.21	$ 10,438.50	$1,978,862.59

CITY O? FRANKLIN, OHIO

SOLID WASTE AND FIBER RECOVERY PLANT

BREAKDOWN OF CONSTRUCTION COSTS BY OPERATION CENTERS

ACTUAL COSTS

Item	Unreimbursed Work For City	Solid Waste Plant	
		Weighing and Receiving	Hydrapulping And Separation
Process equipment	$ 2,250.00	21,127.00	$ 339,720.00
Construction			
General construction	$ --	94,782.06	68,517.15
Mechanical construction	779.00	9,079.00	142,523.00
Electrical construction	--	9,840.00	55,249.99
Fire protection	--	4,350.00	--
Sound system	--	166.00	334.00
Sub-total	$ 779.00	$118,217.06	$ 266,624.14
Miscellaneous equipment	--	20,056.94	17,099.48
Total construction and equipment	$ 3,029.00	$159,401.00	$ 623,443.62

Solid Waste Plant		Fiber Recovery Plant	General Site Improvements (Charged to MCD)	Totals
Fluid Bed Reactor	Solid Waste Plant Total			
$399,000.00	$ 759,847.00	$182,477.00	$ --	$ 944,574.00
$ 65,091.29	$ 228,390.50	$ 72,520.00	$ 3,465.50	$ 304,376.00
117,011.00	268,613.00	97,977.00	6,973.00	374,342.00
35,057.73	100,147.72	46,623.86	--	146,771.58
--	4,350.00	--	--	4,350.00
167.66	667.66	--	--	667.66
$217,327.68	$ 602,168.88	$217,120.86	$ 10,438.00	$ 830,507.24
--	37,156.82	2,494.80	--	39,651.62
$616,327.68	$1,399,172.70	$402,092.66	$ 10,438.50	$1,814,732.86

The construction costs were tabulated from the original fixed price contracts to which was added the amount of the various change orders. A substantial number of change orders were issued which is not unusual for a developmental project such as this, where scale-up problems must be solved while construction and operation is proceeding.

The original fixed price contracts exceeded original estimates of plant cost because the early estimates were based on preliminary flow sheets and equipment arrangements. The final design of the plant included many items such as the plant service truck, hoppers, air compressors, fuel oil storage and supply system which were not envisioned in early estimates. The sizes and space requirements for some equipment turned out to be larger than initially anticipated, particularly in the case of the fluid bed reactor and its ancillary equipment.

The construction cost figures shown in the following table are estimated for a 150 ton per day plant similar to the Franklin plant but built without Federal assistance at 1972 prices. They are based on The Black Clawson Company estimates that a complete, installed plant identical to the Franklin plant would cost about $3,000,000. This estimate includes building, foundations, process equipment, reactor, auxiliary equipment, instruments, controls, and engineering for complete functional Hydrasposal and Fibreclaim plant, but does not include cost of land, nor does it include cost of any standby equipment.

PROJECTED CONSTRUCTION COSTS FOR

SIMILAR FACILITY BUILT IN 1972

150 Ton per day plant estimated at 1972 costs	Hydraposal	Fibreclaim	Total
Process equipment	$ 1,140,000	$ 360,000	$ 1,500,000
Construction			
General construction	$ 340,000	$ 120,000	$ 460,000
Mechanical construction	400,000	160,000	560,000
Electrical construction	150,000	70,000	220,000
Sub-total	$ 890,000	$ 350,000	$ 1,240,000
Miscellaneous equipment	55,000	5,000	60,000
Total construction and equipment	$ 2,085,000	$ 715,000	$ 2,800,000
Engineering	165,000	35,000	200,000
Total	$ 2,250,000	$ 750,000	$ 3,000,000

B. Actual and Projected Operating Costs

1. Tabulated Cost Data

The following two pages show the operating cost analysis, exactly as reported by Black Clawson Fibreclaim, Inc. These cost figures are reported to be the actual expenses paid by the operating contractor during the period noted. To avoid misleading the reader, the authors have prepared an additional table of "Estimated Total Operating Costs", which includes certain additional costs which have been paid directly by the City of Franklin, and which should be included in the cost of plant operation. These charges include insurance, debt service on the total investment, and cost of city water. This table is presented immediately following the Black Clawson Fibreclaim, Inc., report.

BLACK CLAWSON FIBRECLAIM, INC.
SUMMARY OF INCOME AND EXPENSE - FRANKLIN PLANT
MAY 17, 1971 THROUGH AUGUST 31, 1972

COLUMN

I. Actual operating revenues and costs of the Franklin Plant period above. The Tonnage disposed of 13,554 was limited to the total supplied by the Franklin community (approximately 40 tons per day) and not the Plant's available capacity (198 tons per day i.e. 9 T/hr. x 22 hrs./day).

II. Projected operating costs for the same period based on present rate of disposal (9 tons per hour x 22 hrs./day x 330 days/yr.) and current rate of fiber yield (14%).

	I		II	
Tons Processed	13,554		65,340	
	AMOUNT	PER TON	AMOUNT	PER TON
INCOME				
Dump Fees	$ 79,932	$ 5.90	$ 385,506	$ 5.90
Metal Sales	13,615	1.00	65,340	1.00
Fiber Sales	4,686	.35	228,690	3.50
Total	$ 98,233	$ 7.25	$ 679,536	$ 10.40
OPERATING EXPENSES				
Labor - Operations	56,988	4.21	141,250	2.16
Labor - Maintenance	30,485	2.25	37,500	.57
Supplies	11,099	.82	16,000	.25
Materials - Repairs & Maint.- Building	4,365	.32	4,365	.07
Materials - Repairs & Maint.- Equipment	80,711	5.95	305,794	4.68
Fuel Oil	2,045	.15	2,837	.04
Power	60,311	4.45	162,697	2.49
Other Expenses	22,464	1.66	33,971	.52
Total	$ 268,468	$ 19.81	$ 704,414	$ 10.78
	$(170,235)	$(12.56)	$(24,878)	$(.38)
Grant Proceeds	$ 113,490	$ 8.37		
Profit (Loss) from operations	$ (56,745)	$ (4.19)		

BLACK CLAWSON FIBRECLAIM, INC.
FOOTNOTES TO STATEMENT

1. Fiber yield during the specified period was 1% in contrast to the present 14% yield. Subsequent to August 30, 1972, the expiring date of the grant period, the Fibreclaim Department of the Franklin Plant has increased the yield using procedures developed in Black Clawson's Middletown, Ohio Pilot facilities.

2. A grant of $145,166 was received from governmental funds during the period covered by this report. The grant's purpose was for both operating and start up costs. The grant was not to exceed two-thirds of the total loss. The total loss including start up costs was in excess of this amount. For purposes of this report the $145,166 grant has been applied up to the two-thirds limitation against the operating loss of $170,235. The remaining $31,676 has been applied against start up expense as explained in Footnote 3.

3. The statement above presents the actual operating cost for the solid waste disposal system at Franklin, Ohio. The statement excludes extraordinary and nonrecurring expenses of $147,108 (net after grant proceeds of $31,676), which were incurred due to start up, special demonstrations and evaluations. Additional costs of $54,421 were incurred in debt servicing payments to the City of Franklin.

TOTAL OPERATING COSTS

Tons Processed	I		II	
	13,554		65,340	
	AMOUNT	PER TON	AMOUNT	PER TON
INCOME				
Dump Fees	$ 79,900	$ 5.80	$ 385,500	$ 5.90
Metal Sales	13,600	1.00	65,340	1.00
Fiber Sales	4,700	.34	228,690	3.50
Total	$ 98,200	$ 7.14	$ 679,530	$ 10.40
EXPENSES				
Operating Labor	$ 57,000	$ 4.16	$ 141,250	$ 2.16
Maintenance Labor	30,500	2.23	37,500	.57
Maintenance Materials - Building	4,500	0.30	4,500	.07
Maintenance Materials - Equipment	81,000	5.91	305,800	4.68
Fuel Oil	2,000	0.15	2,800	.04
Power - Electrical	60,300	4.40	162,700	2.49
Operating Supplies	11,100	0.81	37,500	.57
*Miscellaneous Expenses	3,800	.28	3,800	.06
Insurance	11,300	.82	11,300	.17
Debt Service	195,000**	14.23	195,000	2.98
Water Cost	17,300	1.26	82,900	1.26
Total	$ 473,800	$ 34.55	$ 985,050	$ 15.05
Net Loss	$(380,800)	$(27.81)	$(305,520)	$(4.65)

*Miscellaneous expenses includes office supplies, telephone, plant security and equipment rental.
**6% interest for 25 years.

2. Analysis of Cost Data

The operating cost data presented in the foregoing tables provide an overview for those who are interested only in results of the plant as a whole. For those interested in an academic, in-depth analysis of the costs associated with the various plant subsystems and operations, the data made available for this report are notably deficient, and provide an example of the necessity for establishing and enforcing cost-reporting criteria and procedures at the outset of future demonstration projects. Had these requirements been firmly established before construction began, much more complete and accurate data undoubtedly would have been available.

The cost elements which have been reported reflect an increase over the originally estimated operating costs. The authors attribute this increase to:

1. Increased maintenance and power costs resulting from equipment added to improve fiber yield, reclaim magnetic metals, etc.

2. Higher than anticipated overhead costs on operating labor.

3. Higher cost of makeup water to system due to higher unit cost of city water as compared to the cost of sewage plant effluent water as anticipated; and also due to increased volume of water required.

4. Inflationary trends which occurred from 1969, when the original estimates were made, to the 1971-72 period of this report.

FOR MORE INFORMATION ABOUT THE FRANKLIN PLANT

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